PATENT SPECIFICATION

1,042,337

DRAWINGS ATTACHED.

Inventor:—FREDERICK DONALD GREEN.

1,042,337

Date of filing Complete Specification: Dec. 11, 1962.

Application Date: Dec. 14, 1961. No. 44890/61.

Complete Specification Published: Sept. 14, 1966.

Index at Acceptance:—E1 A1C.

Int. Cl.:—E 04 g 21/00.

COMPLETE SPECIFICATION.

Improvements in or relating to Methods of Erecting Multi-Storey Buildings.

We, TRUSCON LIMITED, a British Company, of 35—41 Lower Marsh, London, S.E.1, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with improvements in or relating to methods of erecting multi-storey buildings.

The invention enables the floors and roof of a multi-storey building to be precast at ground level and subsequently lifted to the positions which they are to occupy in the finished building. This technique offers a number of advantages. For example, it simplies the process of casting the floors, since all the casting is done at ground level. The floors can be cast successively one on top of another in position ready for lifting and this reduces the shuttering required. Furthermore, the method enables construction to be carried out speedily and economically.

According to the present invention, there is provided a method of erecting a multi-storey building including the sequential steps of forming floors of the building at or near ground level; raising together the floors so formed, placing temporary supports beneath the lowest of the said floors, raising the remaining floors together to a higher position, erecting final supports for the said lowest floor and securing the lowest floor to the final support.

The temporary supports may be constituted by load-bearing shutters for the casting of concrete columns constituting the final supports.

[P——— l.]

All the floors of the building may be erected in this way or the method may be used to erect some of the floors leaving the remaining floors to be erected by conventional methods.

Specific examples of the invention will now be described to illustrate the use of methods of construction according to the invention in the erection of buildings having four storeys. The examples will be described with reference to the accompanying drawings, in which:—

Figs. 1(a) to 1(m); Figs. 2(a) to 2(m); and Figs. 3(a) to 3(m) illustrate diagrammatically three methods of construction according to the invention.

Referring to Figs. 1(a) to 1(m), there are shown parts of the floors 1 to 3 and the roof 4 of a building under erection, the same parts of the floors and roof being shown in all the figures. Briefly, after the ground floor 5 has been prepared, the floors 1 to 3 and the roof 4 are cast in concrete at ground level. In Fig. 1(a) this part of the building process has been completed. The floors and roof are then lifted to the positions they are to occupy in the building by means of a number of jacking units one of which is indicated by the reference numeral 6 in Figs. 1(b) to 1(m). The floors and roof are secured to the jacking units 6 by means of bolts 7 placed in position before the floors are cast as shown in Fig. 1(a). The jacking units are supported on tubular lifting posts 8 accommodated in apertures in the floors and roof and resting on the ground floor 5.

In a typical case, using floors 5-in. thick, 12 jacking units are used for lifting three floors and a roof which measure 30 ft. by

50 ft. The floors may be formed with a waffle construction, that is a grid of thick concrete supports with an integral concrete floor, to reduce their weight, and if this is done, floors with a greater area may be lifted with the same number of jacking units. In some cases equipment and prefabricated parts to be used in constructing the building may be placed on the roof slab and raised with the roof.

In making the floors and roof, the foundations of the building are first prepared and the ground floor 5 is cast in concrete and allowed to harden. Shuttering (not shown) is then placed in position around the ground floor to enable the remaining floors and the roof of the building to be cast on top of the ground floor which itself constitutes the bottom of the mould for the first floor 1. The shuttering includes provision for forming apertures in the floors 1 to 3 and the roof 4 to accommodate the tubular posts 8 which support the jacking units 6 and allow them to rest on the ground floor.

Before the first floor 1 is cast, the ground floor 5 is covered with a thin sheet of synthetic plastic material, e.g. polythene sheeting, or with paper or a parting compound, for example, liquid wax, foundry parting powder, or a resin based parting compound, in order to ensure that the first floor will be separable from the ground floor. The bolts 7 for securing the jacking units 6 to the floors 1 to 3 are also placed in position before casting. Four screw-threaded bolts 7 are provided for each jacking unit 6 and are arranged around the shuttering which forms the apertures for the lifting posts 8.

The bottom end of each bolt 7 carries a nut and a washer (not shown) accommodated in a hole let into the ground floor. The nut and washer are placed in position before the first floor 1 is cast and support this floor during lifting.

A further nut and washer (not shown) are fitted on each bolt 7 in such a position that they will be accommodated in a hole formed in the upper surface of the first floor when it is cast and this second nut and washer will support the second floor 2 during lifting. Similar nuts and washers are provided on all the bolts 7 to support the floor 3 and the roof 4.

The shanks of the bolts 7 are prevented from becoming embedded in the concrete of the floors by metal tubes which are fitted over the bolts between successive nuts and washers.

After the preparations described above have been carried out, the first floor is cast and allowed to harden. The second floor is then cast on top of the first floor and so on until all the floors and the roof have been cast. This stage of erection has been reached in Fig. 1(a).

The tubular lifting posts 8 and the jacking units 6 are now placed in position as shown in Fig. 1(b). Each post 8 is more than two storeys in height and is arranged vertically resting on a bearing plate (not shown) on the ground floor 5. The posts 8 are screw-threaded and each supports one jacking unit 6 for lifting the floors and roof.

One form of jacking unit 6 (not shown in detail) which may be used in carrying out the present method will now be described.

The unit comprises a lower horizontal beam and an upper horizontal beam through which the lifting post 8 extends and which can move freely over the post. Two internally screw-threaded nuts which are engaged on the screw-thread of the lifting post are located one beneath each beam to support the beam on the post. The two beams are interconnected by two hydraulic single-acting 25-ton jacks with a 6-in. stroke, the cylinders of the jacks being secured to the lower beam and the rams to the upper beam.

Apertures are provided in the upper beam to accommodate the top ends of the bolts 7 and the floors 1 to 3 and the roof 4 can thus be bolted to the upper beams of the jacking units.

From each end of the upper beam, two pieces of mild steel angle project downwardly and away from each other. At their bottom ends, the pieces of mild steel angle are bent to form horizontal flat surfaces for engaging against the upper surface of the roof 4 during lifting. The roofs and floors can thus be drawn up against the pieces of angle iron by the bolts 7 with the result that the jacking units 6 and the floors 1 to 3 and the roof 4 form a relatively rigid structure during lifting.

The lower beams of the jacking units are also provided with downward extensions for engagement against the upper surface of the roof and the internally screw-threaded nut referred to above which is engaged on the corresponding lifting post below each of the lower beams is located above the upper surface of the roof 4 between the said downward extensions of the lower beam.

The nut below each lower beam and the nut below each upper beam are arranged to be rotated and screwed along the lifting posts by electric motors mounted on the respective beams. The drive to the nuts includes a chain and sprocket drive but the final drive is by gear wheel which allows the nut to move along the lifting post for a short distance independently of the drive motor.

Each jacking unit operates in the following way.

Hydraulic fluid is supplied to the two cylinders and the pistons of the jacks are forced upward carrying with them the upper

beam and the floors secured to it. As the upper beam moves upward, the nut beneath it is arranged to be rotated by the corresponding electric motor with the result that the nut follows the upper beam as it rises. Thus, if the jacks fail, the upper beam cannot fall but will be supported by the nut beneath it.

When the jacks have completed their stroke, the upper beam is allowed to rest on the nut beneath it and the electric motor connected to the nut beneath the lower beam is started. The motor rotates this nut and raises the lower beam until the jacks are again retracted and in a position to carry out another lifting stroke.

The pumps for supplying hydraulic fluid to the jacks and the electric motors are arranged to be operated from a central control board (not shown) are located on the roof 4. In raising the floors and roof, all the jacks are operated together at the same rate to maintain the floors and roof horizontal and ensure that the load is evenly distributed. Any change in level of a jacking unit relative to the control board is indicated as follows. A transparent tube is secured in a substantially vertical position at the control board and is connected by a further tube to a relatively substantially larger diameter tube secured at or near the jacking unit.

The tubes are partly filled with liquid and the two end tubes are open to the atmosphere.

With such an arrangement, a small change in the level of the jacking unit relative to the control board will produce a relatively small change in the level of the liquid in the large diameter tube, and a relatively large change in the level of the liquid in the transparent tube. The change in level can thus be easily detected and measured.

As a safety measure, switches are incorporated in the circuits controlling the motors for supplying hydraulic fluid to the jacks which make it impossible to operate the motors unless the nuts below the upper and lower beams of each jack are in contact with their respective beams.

After the lifting posts 8 and the jacking units 6 have been placed in position and the jacking units have been bolted to the floors 1 to 3 and the roof 4, the connections for the electric motors for driving the nuts on the jacking units and the connections for the supply of hydraulic fluid to the jacks are put in order and lifting can then be begun (see Fig. 1 (б)).

To lift the floors and roof, the jacking units 6 are operated as described above. The jacking speed during the 6-in. stroke is approximately 1¾-in. per minute. After each 6-in. stroke the lower beam of each jacking unit is raised as described above and another 6-in. stroke is begun.

The floors and roof are raised until the lowest of the three floors 1 to 3, i.e. the floor 1, is approximately ½-in. above the position it is intended to occupy in the finished building. This position has been reached in Fig. 1(c). In the construction method at present being described, the floors and roof are to be supported on concrete columns. Reinforcement 9 for the columns from the ground floor to the first floor is now fixed and shuttering 11 for these columns capable of supporting the load of the floor 1 and constituting a temporary support for the floor is then placed in position around the lifting posts 8. The floors and roof are then lowered until the first floor 1 is supported by the load-bearing shutters 11 as shown in Fig. 1(d).

The nuts and washers beneath the first floor 1 are then removed and lifting is recommenced. The remaining floors 2 and 3 and the roof 4 are lifted to a position in which the second floor 2 is approximately ½in. above the position it is to occupy in the finished building (Fig. 1(e)), and further reinforcement 12 and shuttering 13 is placed in position around the lifting posts 8 to provide temporary support for the second floor 2 which is then lowered onto the shuttering 13.

The first and second floors are at this stage both temporarily supported on load-bearing shutters 11 and 13.

One panel in each of the upper columns of shuttering 13 is now removed and preparations are made to introduce concrete into the lower columns of shuttering 11. First, the electric motors for rotating the nuts beneath the lower beams of the jacks are switched on to run in reverse with the result that the lifting posts 8 are drawn up until they are clear of the first floor (Fig. 1(f)). In order to enable the posts 8 to be lifted, they must be constrained to prevent them from rotating with the nuts. During this operation, the nuts move downward for approximately ½-in until each bears on a corresponding plate which is placed over the aperture in the roof below each jacking unit 6 before the unit is bolted in place. As mentioned above, the drive to the nuts is so designed as to allow this movement of the nuts. The drive is also arranged so that the friction clutch will not operate during lifting of the post 8.

One method of preventing the lifting posts from rotating is as follows.

Two straight grooves are cut along each post 8 in diametrically opposed positions on it and two projections are provided on each beam of the jacking unit 6 for engagement one in each of the grooves. The post and

jacking unit can thus slide, but not rotate, relatively to one another.

In addition to preventing the lifting post from rotating, the arrangement described above in which projections are provided on both beams also gives the two beams of the jacking unit resistance to forces tending to rotate them relatively to one another.

When the lifting posts 8 have been raised as shown in Fig. 1(f), splice bars (not shown) are introduced across the joint between each two columns of shuttering to splice together the concrete columns supporting the first and second floors. Splice bars 14 (Fig. 1(a)) will also normally be set in the foundations so as to project upwardly into the shuttering 11 and splice the lower concrete columns 17 to the foundations.

When the upper splicing bars are in position, pouring is begun and the lower shuttering is filled with concrete. The columns must be formed with accurately level upper surfaces to provide a satisfactory surface for the bearing plates of the lifting posts to rest on.

When the lower concrete columns have hardened the temporary shuttering 11 around the columns is removed and the lifting posts 8 are lowered onto the columns (Fig. 1(g)). The third floor 3 and the roof 4 are then raised until the third floor is approximately ½-in. above the position it is to occupy in the finished building (Fig. 1(h)). Reinforcement 15 and load-bearing shuttering 16 is placed in position around the lifting posts 8 between the second and third floors 2 and 3 and the third floor 3 is lowered until it is supported by this shuttering 16.

The lifting posts 8 are then raised clear of the second floor (Fig. 1(i)) and after further splice bars (not shown) have been placed in position between the second and third floors, the concrete columns 18 between the first and second floors are poured.

When these columns have hardened, the lifting posts 8 are lowered onto them (Fig. 1(j)) and the roof 4 is raised and supported on further load-bearing shuttering as shown in Figs. 1(l) and 1(m). It remains only to remove the jacking units 6 and lifting posts 8 and the columns between the second and third floors and between the third floor and the roof can then be poured. The floors of the building are then in their correct positions supported on concrete columns.

The building is completed in the usual way.

Although in the method just described the devices for lifting the floors have been described as jacking units, other lifting devices supported on posts or in other ways may be used.

In order to steady the floors as they are being lifted, a pair of hydraulic struts may be connected to the centre of each edge of the first (i.e. the lowest) floor. The struts are secured to the ground floor near a lifting post. As the floors are raised, the struts extend and they are urged into the extended position by hydraulic fluid supplied from an accumulator. They are each provided with a non-return valve so that they will remain extended even if the pressure in the accumulator falls.

An alternative arrangement for bracing the floors as they are being lifted is as follows.

A bracing member is pivotally secured on one floor and is pivotally connected to the next floor, the latter pivot being located in a slideway so that this joint can take only vertical loads. A second bracing member half as long as the first is pivotally connected to the centre of the first bracing member and is also pivotally secured to the said next floor at a point vertically above the pivotal connection of the first bracing member to the said one floor.

This arrangement of bracing members allows the floors to move apart but provides the necessary resistance to lateral forces.

The above-described arrangements for bracing the floors during lifting may also be used in the two further methods described below.

When the first floor 1 has been secured in position, similar pairs of struts are secured to the second floor 2, the lower ends of the struts being in this case secured to the first floor. Successive higher floors are also provided with struts in a similar way.

In order to make the lifting posts 8 more rigid, a restraint may be provided near the centre of each post when the first floor has been lifted into position. Restraints may also be provided in similar situations higher up.

Two further methods for raising the floors will now be described with reference to Figs. 2(a) to 2(m) and 3(a) to 3(m) which shows views similar to those of Figs. 1(a) to 1(m). These methods employ apparatus similar to that described above, but make use of slightly different arrangements for temporarily supporting the floors during construction and in the case of the method shown in Figs. 3(a) to 3(m) also for providing the final supports for the floors.

In the method illustrated in Figs. 2(a) to 2(m), the lifting posts 19 have a height only a few feet greater than the height the lowest floor 20 is to be placed at. The floors 20 to 22 and the roof 23 are formed in the manner described above and are lifted until the lowest floor 20 is ½-in. above the position it is intended to occupy in the finished building (Fig. 2(c)). Reinforcement 25 for the concrete columns to support the first floor 20 is then placed in position and load-

bearing shutters 26 constituting a temporary support for the floor are also placed in position. The reinforcement 25 and shutters 26 may be placed anywhere except at those positions occupied by the lifting posts 19. The floors and roof are then lowered onto the load-bearing shutters 26 (Fig. 2(d)) and the lifting posts 19 are raised to allow plain unthreaded tubes 27 to be placed beneath them (Fig. 2(e)). The tubes 27 are wedged in the apertures formed in the first floor 20 to allow the lifting posts to extend through the first floor. The threaded lifting posts 19 are arranged to rest on the plain tubes 26 and restraints (not shown) are provided near the tops of the plain tubes.

The floors 21 and 22 and the roof 23 are then raised until the second floor 21 is in a position ½-in. above the position it is intended to occupy in the finished building (Fig. 2(f)) and concrete is poured into the shutters 26 placed in position below the first floor 20 to form concrete columns 40 for supporting this floor. The concrete is poured through apertures 41 formed in the floors and roof when they are cast at the places where the columns are to be located. The reinforcement 25 for the lower concrete columns is of such a length that it projects through the apertures 41 in the first floor 20 to form splice joints between the lower columns 40 and columns 42 to be formed between the first and second floors 20 and 21.

Reinforcement 28 and shutters 29 are then placed in position for the pouring of the next series of columns and the floors 21, 22 and the roof 23 are lowered onto the shutters 29 (Fig. 2(g)). The threaded lifting posts 19 are raised and a second set of plain tubes 32 are placed beneath the lifting posts 19 and are wedged into the apertures for the lifting posts left in the second floor 21. The lifting posts 19 are arranged to rest on the plain tubes 32 and 27 which thus take the weight of the floors during lifting (Fig. 2(h)).

Further reinforcement 34 and load-bearing shutters 35 are placed in position beneath the third floor 22 and the floor 22 and the roof 24 are lowered onto the shutters 35 (Fig. 2(j)). A further length 36 of plain tube is then introduced (Fig. 2(k)) and the roof 23 is raised (Fig. 2(l)). The concrete columns 43 between the second floor 21 and the third floor 22 are next poured and reinforcement 37 and load-bearing shuttering 38 is placed beneath the roof 23 (Fig. 2(m)). The jacking units 6 and lifting posts 19 are then removed and the upper concrete columns are poured.

In the method illustrated in Figs. 3(a) to 3(m), the lifting posts 49 again only have a height a few feet greater than the height of the first storey.

After the floors and roof have been cast and before lifting is begun, a small mobile crane is placed on top of the roof slab together with precast concrete columns to be used as final supports for the floors and roof. Sections of temporary towers to be used as temporary supports for the floors and roof are also placed on top of the roof slab. The floors 50 to 52 and the roof 53 are then lifted until the first floor 50 is ½-in. above its intended final position (Fig. 3(c)) and temporary towers 55 are erected around the lifting posts 49. The floors and roof are lowered until they are supported on the towers 55 which constitute temporary supports for the lowest floor 50 (Fig. 3(d)).

The temporary towers are split longitudinally into two sections which are lowered one by one through apertures 56 left in the floors and roof near to the lifting posts. Two sections of a tower are positioned on opposite sides of each post 49 and the sections are bolted together to form the complete tower.

The lifting posts 49 are now raised and their lower ends are arranged to rest on beams 61 inserted near the top of the towers 55 (Fig. 3(e)). The floors 51 and 52 and the roof 53 are then raised until the second lowest floor 51 is approximately ½-in. above its intended final position and precast reinforced concrete columns 70 are lowered through the apertures 56 onto splice bars 58 set in the ground floor (Fig. 3(f)). Grout is forced into sockets in the precast columns 70 which accommodate the splice bars 58 and the aperture 56 above each column 70 is filled with concrete, splice bars 59 being first placed in sockets formed in the tops of the concrete columns and grouted in (Fig. 3(g)).

Temporary towers 60 are lowered through the apertures 56 in the floors 51 and 52 and the roof 53 and are placed round the lifting posts 49. The towers 60 rest on the floor 50 and support the second floor 51. The floor 51 is then lowered onto the temporary towers 60 and the lifting posts 49 are raised and their lower ends are arranged to rest on beams 62 inserted in the temporary towers (Fig. 3(h)).

The floor 52 and the roof 53 are now raised until the floor 52 is ½-in. above its intended final position. Precast reinforced concrete columns 71 are then lowered through the apertures 56 in the floor 52 and the roof 53 and in the floor 51 onto the splice bars 59 (Fig. 3(h)). The splice bars are grouted in and the apertures 56 in the floor 51 are filled in, further splice bars 64 being positioned in the tops of the columns 71. The sequence of operations is continued in a similar manner, as illustrated in Figs. 3(j) to 3(m).

When the roof has been raised to its final

position as shown in Fig. 3(m), there is no need to support it on temporary towers. Precast concrete columns are lowered through the apertures 56 in the roof 53 and the weight of the roof is transferred directly to these columns from the lifting posts.

In the methods illustrated in Figs. 2(a) to 2(m) and 3(a) to 3(m), the apertures left in the floors and roof to accommodate the lifting posts have to be filled in after lifting is completed. The building is then finished in the usual way.

One advantage of the two additional methods just described is that the minimum size of the concrete columns is not governed by the minimum size of the shutters which can be placed around the lifting posts and the final supporting structure need not, therefore, differ from the supporting structure of a building erected in a conventional manner. Steel stanchions may be used instead of precast concrete columns as the final supports. In that case, each floor will be secured to the corresponding stanchions after the floor has been raised and the stanchions have been placed in position.

WHAT WE CLAIM IS:—

1. A method of erecting a multi-storey building including the sequential steps of forming floors of the building at or near ground level, raising together the floors so formed, placing temporary supports beneath the lowest of the said floors, raising the remaining floors together to a higher position, erecting final supports for the said lowest floor and securing the lowest floor to the final support.

2. A method according to claim 1 including the additional step of placing temporary supports beneath the second lowest of the said floors, after raising the said remaining floors to the said higher position, before erecting the final supports for the lowest floor.

3. A method as claimed in claim 1 or 2, wherein the temporary supports are constituted by load-bearing shutters for the casting of concrete columns which constitute the final supports.

4. A method as claimed in claim 1, 2 or 3, wherein the floors are raised by means of lifting devices supported on posts.

5. A method as claimed in claim 4, wherein the said posts are of a height sufficient for raising the pre-formed floors to the level of the second floor.

6. A method as claimed in claim 4 or 5, wherein the temporary supports and the final supports are erected at positions other than around the posts supporting the lifting devices.

7. A method as claimed in claim 4, wherein the posts are themselves raised by means of the lifting devices after the temporary supports have been placed beneath the lowest floor, the remaining floors and the lifting devices being supported on this floor during raising of the lifting posts, and wherein further supports are thereafter placed beneath the raised posts to support them before the remaining floors are raised to a higher position.

8. A method of erecting a building substantially as hereinbefore described with reference to Figs. 1(a) and 1(m) of the accompanying drawings.

9. A method of erecting a building substantially as hereinbefore described with reference to Figs. 2(a) to 2(m) of the accompanying drawings.

10. A method of erecting a building substantially as hereinbefore described with reference to Figs. 3(a) to 3(m) of the accompanying drawings.

REDDIE & GROSE,
Agents for the Applicants,
6, Bream's Buildings,
London, E.C.4.

Abingdon: Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1966.
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2,
from which copies may be obtained.

Fig.1.

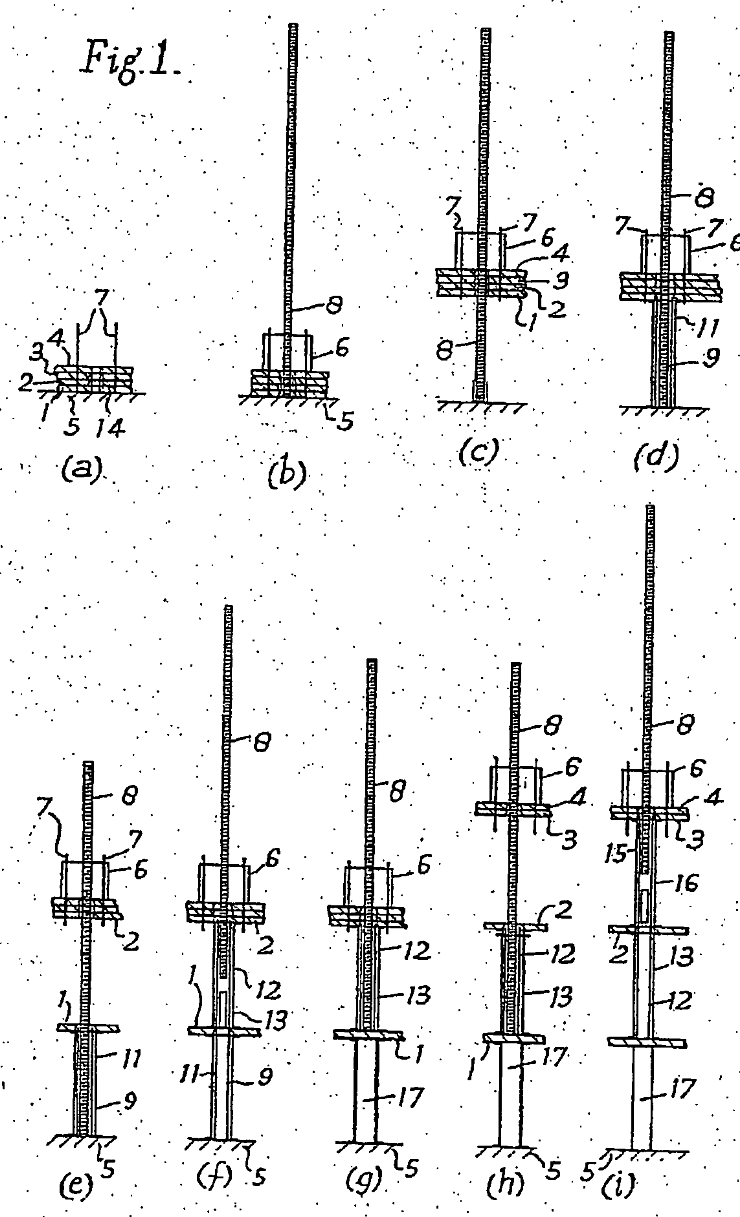
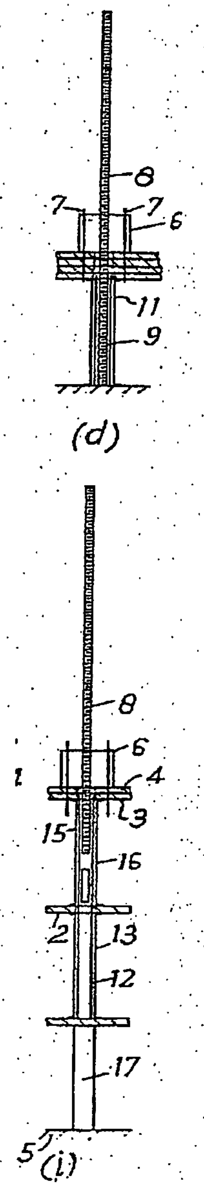


Fig.1.



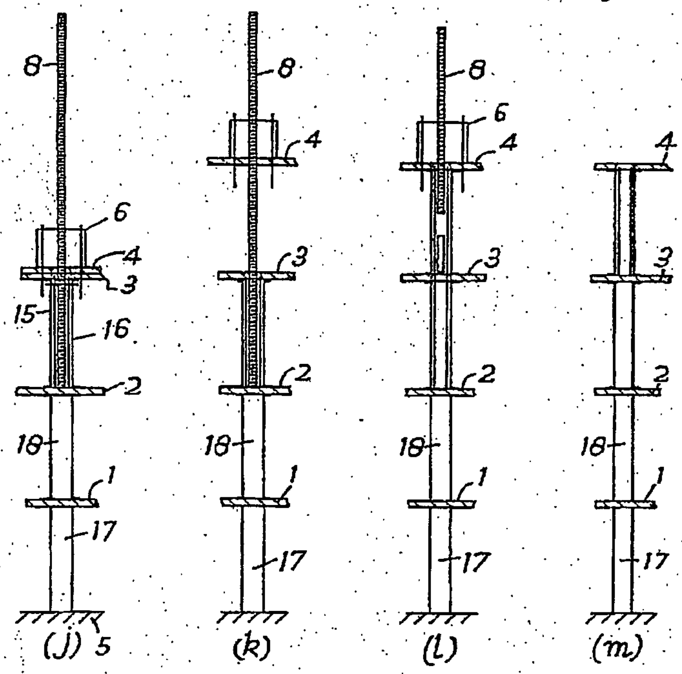
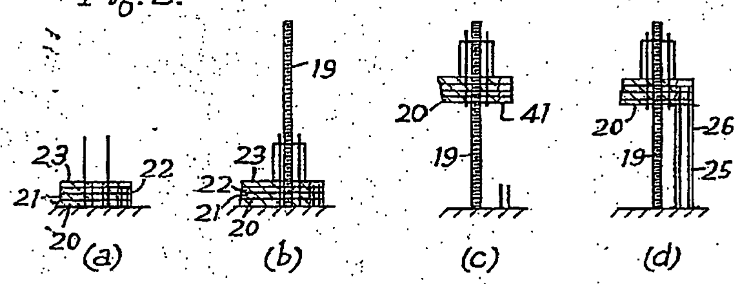


Fig.2.



1042337 COMPLETE SPECIFICATION
5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 1 & 2

Fig. 1.

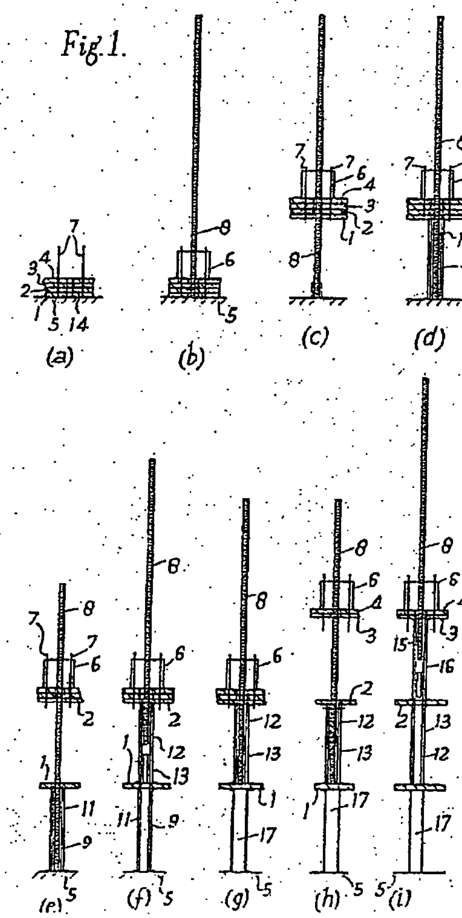


Fig. 1.

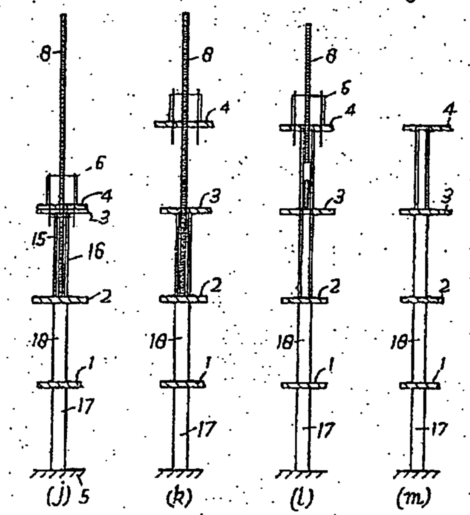
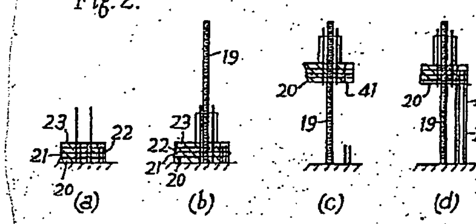


Fig. 2.



7

1042337 COMPLETE SPECIFICATION
5 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 3 & 4

Fig.2.

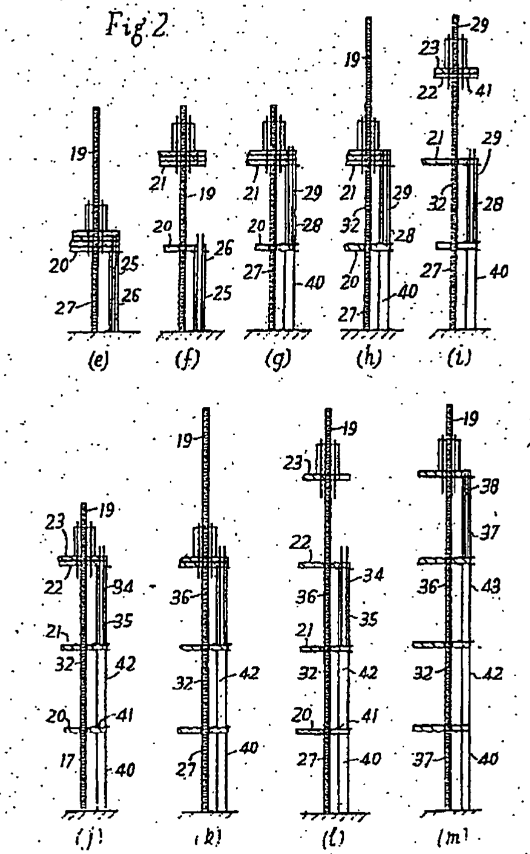


Fig.3.

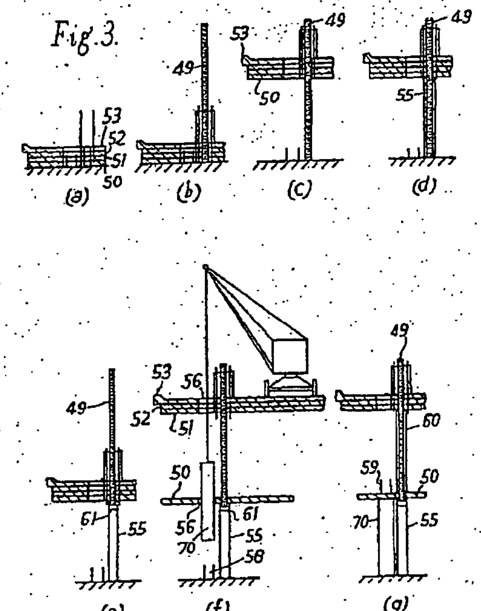
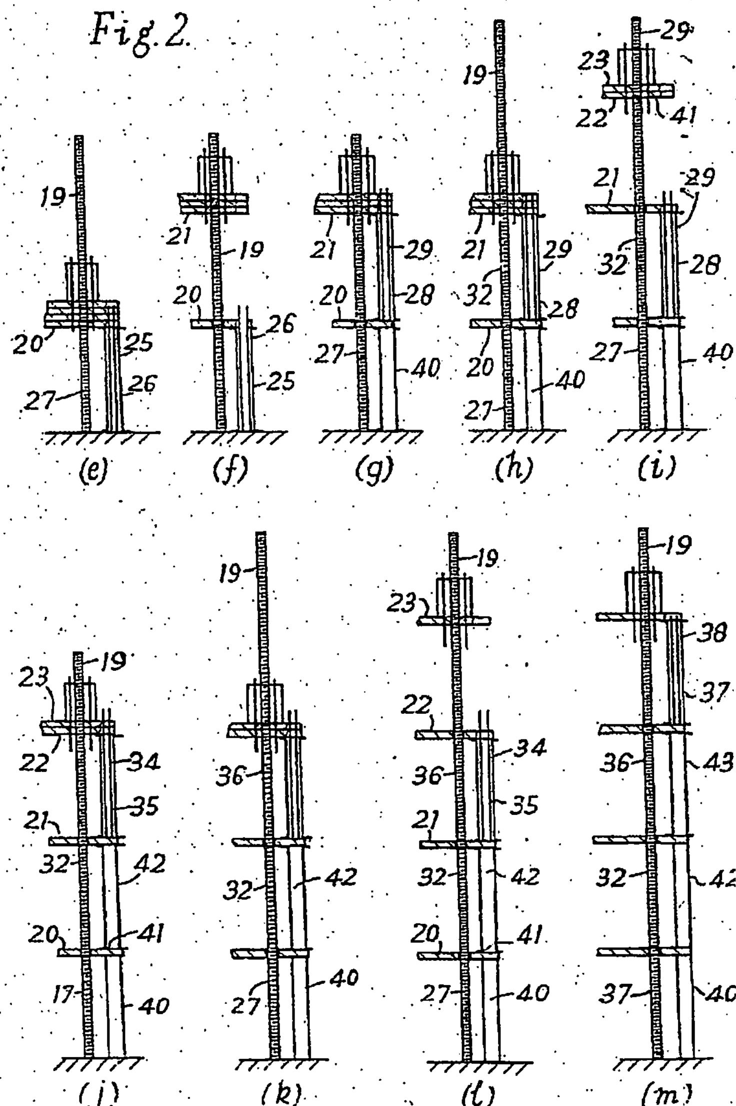


Fig. 2.



19
20
25
26
27
(e)
21
19
20
26
25
(f)
21
29
20
28
27
40
(g)
19
21
29
32
28
20
27
40
(h)
29
23
22
41
21
29
32
28
27
40
(i)
19
23
22
34
35
21
32
42
20
41
17
40
(j)
19
36
32
42
27
40
(k)
19
23
22
34
36
35
21
32
42
20
41
27
40
(l)
19
38
37
36
43
32
42
37
40
(m)

1042337 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 3 & 4

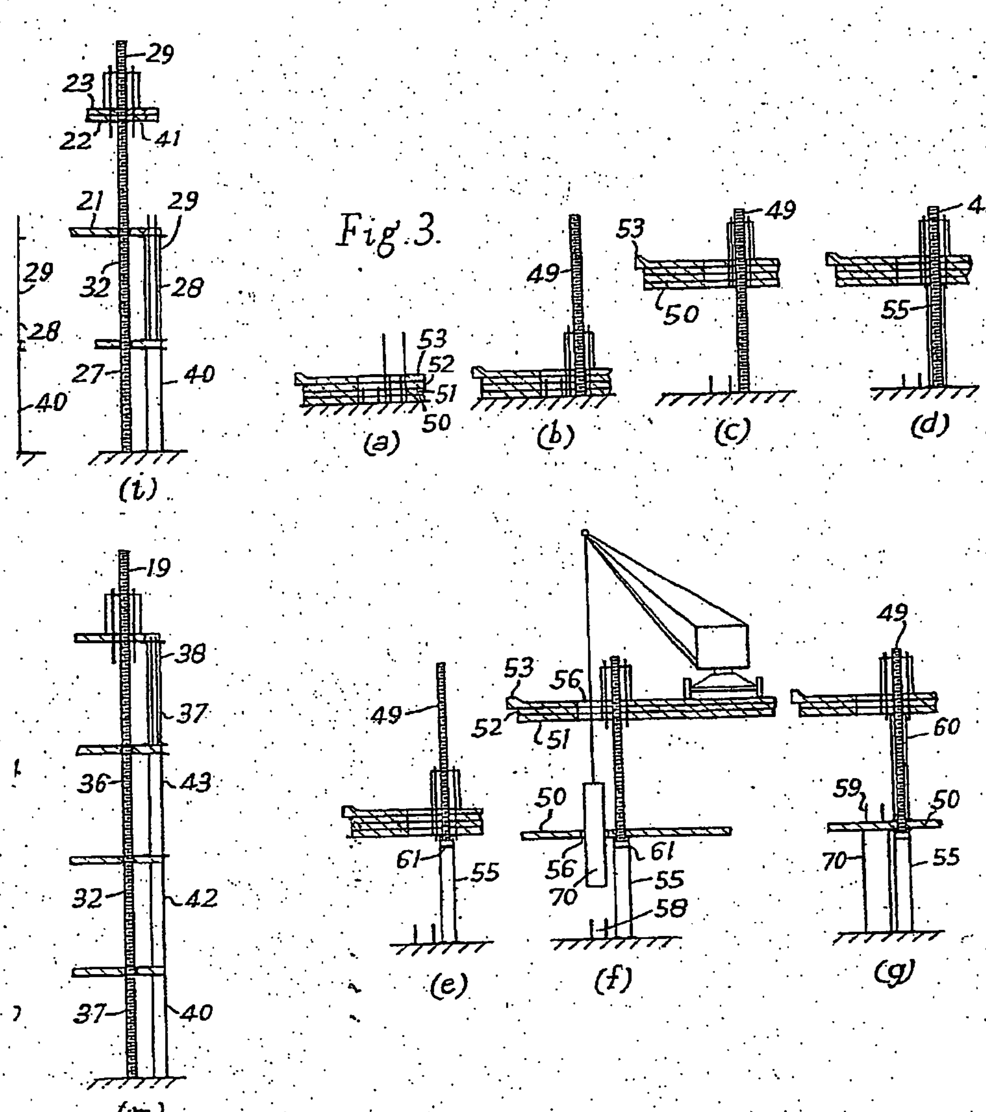


Fig. 3.